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Gaining Insight into IT Investment in the Agriculture Industry: Comparison of IT Portfolios by Type of Crops

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ABSTRACT

IT portfolio, meaning the ratio of investment with four different purposes of IT, is widely used for evaluating the adequacy of investment and its performance within firms. Despite of such a useful framework looking at investment on IT, IT portfolio in agriculture industry seems to be differentiated from other industries. In this study, we compared IT portfolios of farms: grain, field fruit and vegetable, greenhouse fruit, greenhouse vegetable, beef cattle and pig. We classified farms by their return on equity (ROE) in order to analyze the relationship between IT portfolio of each crop and performance. Then, we found patterns of IT portfolios of top-performance farms compared to all farms for each agricultural product. Lastly, peculiarities of each crop are interpreted and discussed to find out top-performance farms' IT investment patterns. From our study, it could be inferred that monotonous IT investments may not be as effective.

Keywords: IT Portfolio, IT Investment, Agriculture IT

Ⅰ. Introduction

Investment into Information communication technology(ICT) is believed to be a panacea for improving the performance of farms. Accordingly, in many countries, there have been government-driven efforts to informatize farms and rural areas. In Japan, for example, agricultural informatization began with the central government-led rural informatization policy called "Greentopia" (Cheung, 1991; Choe and Moon, 2003). Since the 1970s, the Chinese government has been carrying out a three-step agricultural informatization policy (Qiang, 2009).

However, there has been criticism as to whether

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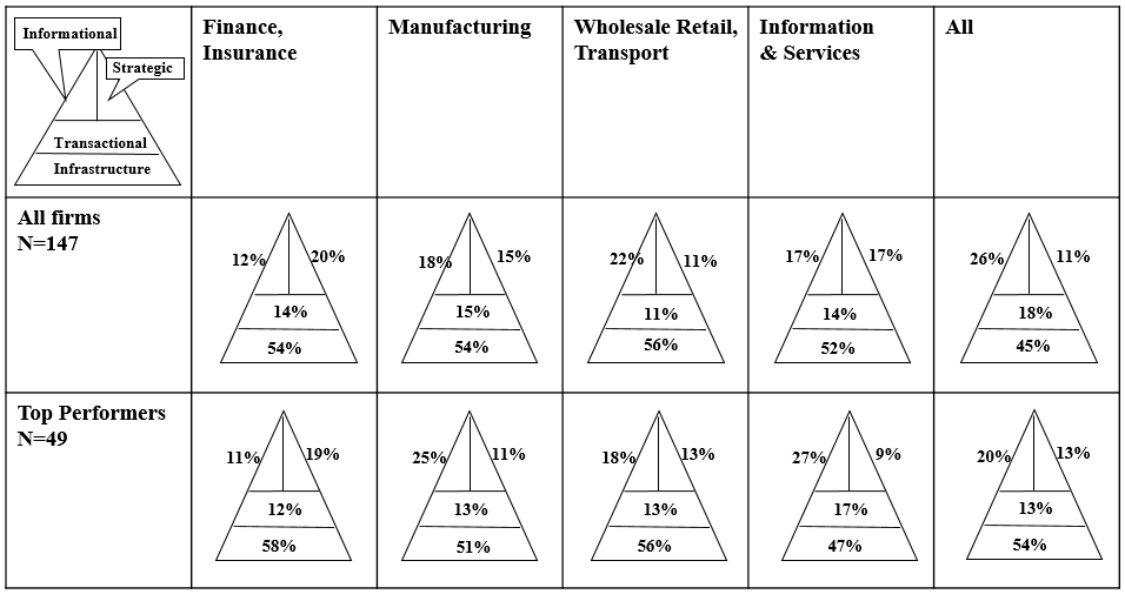
increase in IT investment is really effective; Weill and Aral (2005) have argued for the need to analyze distinct asset classes in IT investment. An IT portfolio represents a company's investments into four management objectives: transactional, informational, strategic, and infrastructural. IT portfolios take different forms in the different industrial sectors (Weill and Aral, 2004). Compared with other industrial sectors, agriculture is an industry of small firms, and is organically and closely linked from production to distribution. In such a process, the role of ICT is clear in effectively increasing the performance of farms. Despite this obvious role, informatization activities in agriculture have not always fit the needs of farms, and some investments have been indiscreet and unsuitable.

Despite of the excellence of the concept of IT portfolios differently applied to each industry, agriculture industry needs to be more carefully addresses due to the versatile nature of agriculture. Does a farm's IT portfolio depend on the type of crop? Do unsuitable investments make a difference? For example, the effects of introducing automatic milking systems in dairy farms, and those of introducing dairy farm management systems into soybean farms cannot be the same. Although agriculture is a word, each crop actually has a different production purpose, cultivation method, release date, and distribution. Farms cannot make the same IT investment for a strawberry grown in the field and a strawberry grown in a greenhouse.

This research compared the IT portfolios of farms producing various agricultural products, and classified farms by their return on equity (ROE) in order to analyze the relationship between IT portfolio of each crop and performance. We then found patterns of IT portfolios of top-performance farms compared to all farms for each agricultural product., and interpreted which features of each product influenced top-performance farms' IT investment pattern. The first section explains why IT portfolios are used in this study, and provides an example of agricultural IT for each component of the IT portfolio. This is followed by the methodology, and finally an analysis of the results.

Ⅱ. Research Background

The concept of the portfolio comes from the field of financial management (Archer and Ghasemzadeh, 1999). Stock investors use portfolios to invest in several stock items and maximize investment returns. This approach can be applied to the IT field, as well as many areas of industry (McFarlan, 1981). The IT portfolio involves investment in four different areas of IT: transaction, information, strategy, and infrastructure (Weill et al., 2009). Transactional IT investments are those into automated construction systems for routine transactions. According to Weill and Broadbent (1998), transactional IT investment leads to reduced costs and an increase in IT skills. In agricultural IT, these systems include automatic adjustment systems, automatic payment systems, and point-of-sale (POS) systems. Information IT investments refer to the investments into decision-making and management systems based on operational information, including financial management, controls, reports, and analyses. Information IT investment can result in better information, an increase in information control, and improved information quality and information integration (Weill and Broadbent, 1998). Examples of agricultural information IT include electronic account books, production management systems and Enterprise Resource Planning (ERP) systems such as inventory control, market in-



<Figure 1> IT Portfolios of All Firms and High Performers in Different Industries (Weill and Aral, 2004)

formation management, materials management, and revenue management. Investment into IT strategy refers to the development of systems to gain a competitive advantage or position in the marketplace. According to Weill and Broadbent (1998), investment into IT strategy allows firms to gain competitive advantages, competitive necessity, market positioning, and increased sales. Examples of agricultural strategy IT include greenhouse and pen automatic control systems, decision-making support systems (e.g., cropping or shipping systems), online shopping management, and SNS management. IT investment into infrastructure refers to investment into IT infrastructure for IT services. It leads to business integration, business flexibility, and standardization, and also reduces IT costs (Weill and Broadbent, 1998). These infrastructures include mobile devices, wireless relay devices, RFID tags, printers, servers, PCs, smart pads, CCTVs, and environmental monitoring sensors.

IT portfolios take on different forms in different areas of industry (Weill et al., 2009) (See Figure 1). Weill and Sinan (2005) found that companies with complete IT portfolios earned higher returns over the course of a four-year follow-up survey. Thus, if we can identify top performers in specific industries, we can determine the most beneficial IT portfolios for those areas.

We used questionnaires on IT portfolios to survey individuals and groups of agriculturists, and compared IT portfolios of top performance farms and to those of all farms for each agricultural product. This research determined top performers based on ROE.

Return on Equity = Net Income/Shareholder's Equity

In doing so, we identified an IT portfolio for each agricultural product and performance levels for evaluating IT investment, and subsequently analyzed the factors influencing these IT portfolio patterns.

Ⅲ. Research Method

This study surveyed farms which made IT investments in 2014. Those farms include agricultural association corporations, agricultural corporations, and individual farmers in South Korea. Agricultural association corporations are organizations which improve productivity by cooperative agriculture management, and have joint shipment, distribution, manufacturing, and export of agriculture products. Agricultural corporations are companies which have agriculture management, shipment, distribution, manufacturing, and agriculture product sales enterprises. Individual farmers are not the form of one-man company but family businesses. Those farm family businesses are not small size compared to small-sized agricultural association corporations and agricultural corporations because those farm family businesses can afford to invest in IT. According to Yoon and Kim (2001), they argued that greenhouse cultivation should be seen as a kind of family business. In addition, firm size does not have a significant effect on IT investment of firms (Chari et al., 2007).

This research used personal interview surveys, which is a good method for achieving a higher response rate (Louise Barriball and While, 1994). The interviewers of Gallup visited farmers and participants. These interviewers of Gallup had professional training for performing interviews. They explained the questionnaires, received the farmers' answers, and recorded the answers. The interviewers explained each area of IT portfolios, identified examples of IT systems in each area, and asked about the percentage of IT investments in each of the four IT portfolio areas. 713 samples had answered ROE which determined to top performers. We compared the IT portfolios of top-performance farms to those of all farms. The next section presents the results of the survey, and an analysis of factors influencing the observed patterns.

Ⅳ. Data Analysis

We collected 713 samples. We focused our analysis on six agricultural product farms: grain, fruit and vegetable (field grown), vegetable (greenhouse grown), fruit (greenhouse grown), beef cattle and pig farms. We categorized those agricultural product farms based on "Survey on the information level and use of agricultural cooperation 2014" which issued by "Korea Agency of Education, Promotion & Information Service in Food, Agriculture, Forestry & Fisheries(EPIS)". We excluded from our analysis several agricultural products that had too small a sample size of top performance farms and/or total farms. For comparisons of IT portfolios between different agricultural product farms, Weill and Aral (2005) suggest a comparison of the IT portfolios of all firms against those of the top performers. This comparison can provide insight and understanding of IT investments, and may improve the performance of this investment.

<Table 1> represented the percentage of each IT portfolio area in total IT investment of farms. The overall top performance farms invested more into transactional and informational IT, and less into strategic and infrastructure IT (See Table 1). However, there are no significant IT portfolio patterns observed in the total number of farms. This result was obtained by analyzing several agricultural product farms at the same time. We must also separately analyze each agricultural product with a sufficient sample size.

In grain farms, top-performance famers and corporations had a higher percentage of investment into information IT than all farms (See Table 2). Top-per-

formers invest in information IT in order to record data for crop operation, and to analyze and report this data when adjusting the variety and ratio of grains. They pay close attention to selecting and modifying their crop variety, as different varieties of crops have different characteristics, such as adaptation to high temperatures, resistance to insect pests, and flood-tolerance (Dar et al., 2013; Datta et al., 1998; Luo and Li, 2007). They are also concerned with the influence of the soil on their crop (Brenchley and Warington, 1933). Before the adoption of IT, those decisions were made based on the individual experiences of each farmer, and were influenced by the choices made by neighboring farms. Today, farmers can receive data of disease and insect infestation, local climate data and other farming related information by information IT (Gomide et al., 1998; Wang et al., 2006), so they can make decisions based on comparative, objective data. It is for these reasons that top-performance farms invest more in informational IT.

In field fruit and vegetable farms, top-performance farms have higher transactional IT investment compared to that of total farms (See Table 3). In field farms, it is difficult to make differentiated crops form other farms, thus investments into informational IT are made to obtain market information and inform decision making. However, transactional IT investment creates a distinction between top-performance and non-top-performance farms. These factors were observed in transaction farmers and stores, illustrating how top-performance field vegetable farms and fruit farms invest in transactional IT to support transaction.

The greenhouse fruit and vegetable farms were compared and analyzed separately (See Table 4 and Table 5). The difference between the two categories is significant because vegetables are short-lived and

<Table 1> IT Portfolios of Total Number of Farms

Performance: Total agriculture	Transaction (%)	Information (%)	Strategic (%)	Infrastructure (%)	Sample Size
Top performers	9.859155	23.23944	12.43662	54.46479	71
Total farms	9.085674	18.73315	15.42275	56.75843	712

<Table 2> IT Portfolios of Grain Farms

Performance: Grain	Transaction (%)	Information (%)	Strategic (%)	Infrastructure (%)	Sample Size
Top performers	9.666667	29.66667	5.666667	55	15
Total farms	7.683824	21.69118	5.845588	64.77941	136

<Table 3> IT Portfolios of Fruit and Vegetable Farms (Field)

Performance: Fruit and vegetable farms(field)	Transaction (%)	Information (%)	Strategic (%)	Infrastructure (%)	Sample Size
Top performers	23.21429	16.78571	5.714286	54.28571	14
Total farms	10.0655	20.93886	8.384279	60.61135	227

<Table 4> IT Portfolios of Fruit Farms (Greenhouse)

Performance: Fruit farms (greenhouse)	Transaction (%)	Information (%)	Strategic (%)	Infrastructure (%)	Sample Size
Top performers	2.5	42.5	22.5	32.5	4
Total farms	11.98413	13.49206	15	59.52381	63

<Table 5> IT Portfolios of Vegetable Farms (Greenhouse)

Performance: Vegetable Farm (greenhouse)	Transaction (%)	Information (%)	Strategic (%)	Infrastructure (%)	Sample Size
Top performers	7.173913043	24.56521739	21.43478261	46.82608696	23
Total farms	8.05914	18.18817	34.65591	39.09677	186

have relatively short cultivation periods, while fruits have relatively long cultivation periods.

Top-performance greenhouse fruit farms have a higher percentage of investment into informational and strategic IT, and less into transaction and infrastructural IT than that of total farms. They glean decision making to adjust the shipping dates, as fruit prices and demand are fluid. There is less product differentiation in fruit produce; however, greenhouses can yield fruits and vegetables that are higher in quality and available out of season. For these fruits, it is possible to develop product distinction through branding and naming (Park, 2007). Many fruit farming corporations and local governments seek to differentiate their brands, like Sunkist and ZESPRI (Yoon, 2011). To achieve this, these corporations invest in strategic IT to gain competitive advantages or positioning in the market. Both famers and corporations have high strategic IT investment, while top-performance farms have an even higher informational and infrastructural IT investment than that of total farms.

Imported agricultural products also influence the shipping period of greenhouse fruit and vegetable farms. Advanced cultivation technology enables farms to change the shipping dates of greenhouse products so that they may avoid the period of foreign fruit and vegetables imports. In the same vein, farmers should consider the shipments of local farms, as well as those in other regions. Investment in informational IT can provide farmers with the information necessary to make these adjustments. In farm management, cost reduction is a critical factor in profit increase. Infrastructural IT investments provide portable devices, RFID tags, CCTV, and environmental monitoring sensors. These IT infrastructures are efficient in reducing costs, such as labor and energy consumption. RFID technology and computing systems, especially, can reduce the amount of effort and attention required from farmers (Ruta et al., 2010). Greenhouse vegetable farms also develop product differentiation through branding and naming, but to ensure optimal decision making, these agriculturalists must focus on information; thus, they invest in informational IT.

In beef cattle farming, top-performance farms have a higher percentage of investment into informational and strategic IT than that of the total number of farms (See Table 6). Informational IT investment

<Table 6> IT Portfolios of Beef Cattle Farms

Performance: Beef cattle	Transaction (%)	Information (%)	Strategic (%)	Infrastructure (%)	Sample Size
Top performers	2.5	22.5	13.5	61.5	10
All farms	7.735849	14.90566	5.377358	71.98113	53

<Table 7> IT Portfolios of Pig Farms

Performance: Pig farming	Transaction (%)	Information (%)	Strategic (%)	Infrastructure (%)	Sample Size
Top performers	6	2	0	92	5
All farms	9.680851	12.12766	12.55319	65.6383	47

is necessary to supplement the farm's decision-making process when they ship their beef cattle and decide on the quantity of beef cattle. Market prices influence the shipment and price of beef cattle, and the cost of fodder influences the quantity of beef cattle (Soung and Kim, 2008). Decreasing beef cattle production costs, especially the fodder costs, is the most effective means of saving costs and increasing profit. Thus, beef cattle farms need to make informational IT investments in order to assess market situations, review the farms' electronic account book, and monitor the production management system. The beef cattle industry is making efforts towards creating a brand in order to increase profit and consolidate competitive power, which will brings costs down and improve quality (Koo and Park, 2012). Branded beef cattle can make a higher profit margin than cattle with no brand. Thus, beef cattle farms make strategic IT investments towards automatic pen control systems, decision- making support systems, and online promotions.

In Table 7, pig farming has a very high percentage of infrastructural IT investment because it requires recorded data for the pen environment (Kim et al., 2011) and environmental monitoring sensors (Park et al., 2011). Several research studies in pig farming have explored strategic IT investments into automatic management systems and automatic shipment systems (Choi, 2015; Hwang et al., 2010; Ketprom et al., 2007; Lee and Choe, 2005; Lee et al., 2008). In this study, we can glean the explanation that top-performance pig farms that had made investments prior to 2014 had only invested in infrastructural IT, such as RFID tags, while investments for environmental monitoring sensors were made in 2014. Those top-performance pig farms may have already invested in other areas, such as informational IT investments like ERP systems, or strategic IT investments like automatized pigpens.

Previous pig farming research proposed several insights which increased profits and reduced the costs of pig farming. Lee and Cho (2013) suggested several strategies for improving pig farms' competitiveness, including implementing a differentiation strategy, and adjusting the shipping date. Today, automatized pigpens and other technologies in the livestock industry have resulted in the production of high quality pork. It is also possible to develop pork product distinction through branding and naming. Strategic IT investment can support the differentiation strategy by managing online shopping and SNS for brand promotion. Adjusting the shipping

date is a very effective method for the reduction of feed consumption (Kim, 1985). Informational IT investment can help to confirm and forecast pork price fluctuations in the market, and determine optimal shipping periods.

Overall, there are many differences between the IT portfolios of top-performance farms and those of total farms. We gain several insights into agricultural products and IT investment by comparing the IT portfolios of each type of farm. First, even if the same product is farmed, there are big differences created by the cultivation environment. In greenhouse fruit and vegetable farms, investment into strategy IT is greater than that into informational and transactional IT. In field fruit and vegetable farms, investment into information IT is greater than that into strategic and transactional IT. The cultivation environment of crops influences the quality of the product and a farm's strategy, so their IT investments have different patterns, as well. Secondly, farms with crop types that can yield high quality products can use differentiation strategies like branding and naming. Investment into strategy IT can support these strategies. Finally, adjusting the shipping date is a very important issue for those farms. Adjusting the shipping date can maximize product price and minimize costs like feed, labor, and heating bills. It also considers other market factors: alternative agricultural products, seasonal consumption, infectious livestock diseases, food trends, and imported agricultural products. In this case, informational IT investment can help to find the optimal shipping date with ERP and production management systems.

Ⅴ. Conclusion and Discussion

Governments around the world are heavily investing into agricultural informatization in order to improve the performance of farms. However, even if IT portfolios are key for measuring the IT investments of farms, there are few research evaluating the result of IT investments in agriculture. This study applied research into IT portfolios in agricultural, and observed IT portfolio patterns in different agricultural product farms. Weill and Sinan (2005) found that companies which have appropriate IT portfolios for the industry achieved higher performance than other companies. Subsequently, we compared the IT portfolios of top-performance farms to those of all farms. After comparing IT portfolios, we explained what caused certain product farms to achieve top-performance IT portfolios.

This research compared means of agriculture IT portfolios. Although this research has less rigor, Dubé and Paré (2003) argued that rigor is not first and only criterion and we propose several implications by applying the IT portfolio concept in agricultural research. This research also describes which factors influence top-performance in the farming of each agricultural product. First, this study can find the IT portfolio pattern of top-performance in each agricultural item. We compared IT portfolios of top-performance farms and all farms producing the same agricultural product. Individual farmers and agricultural corporations can compare their IT portfolios with those of top-performance farms, and thereby adjust their portfolio to support and enhance their IT performance (Weill and Sinan, 2005). Secondly, IT can evaluate a government's agricultural support policies by comparing support targets and top-performance farms. It can give effective feedback on the direction of the agricultural support policy. Finally, IT portfolios can be analyzed by time-series. The IT portfolio survey questionnaires were from "Survey on the Information Level and Use of

Agricultural Corporation 2015", an annual research survey. We can compare the IT portfolios of each year and observe any changes with a longitudinal survey. Thus, IT portfolios are valuable in evaluating IT investment in agricultural areas.

This research also compared IT portfolios in agriculture with those in other industries, and in particular with those in the manufacturing industry, as these are most similar to agricultural IT portfolios. Comparing different agricultural product farms to the manufacturing industry, we find grain farm IT portfolios show patterns analogous to those observed in the manufacturing industry, while greenhouse vegetable farm portfolios differ the most from those in the manufacturing industry. In grain farms, IT investment into decision making and management systems based on operation information influences a farms' performance. Thus, informational IT investment in grain farms is important, just as in the manufacturing industry. In contrast, product differentiation through branding and naming are crucial to gaining a competitive edge for greenhouse vegetable farms. Thus, greenhouse vegetable farms invest in strategic IT investments, unlike the manufacturing industry.

This research provides several insights into the agriculture industry. First, transactional IT investment is important for top-performance in field fruit and vegetable farms, but infrastructural IT is important in greenhouse vegetable farms. In greenhouse vegetable farms, both top-performance farms and greenhouse vegetable farms in general invest more into strategic IT to support product differentiation strategies. Because IT systems for decision making and management support the operation of farms making larger profits, informational IT investment is observed much more in the IT portfolios of top-performance farms than those of all farms. Secondly, informational IT investment is important for top-performance in grain farms, as it relates to operating grain farms. Finally, IT investment in livestock is concentrated in infrastructural IT investment, unlike other agricultural products. This differentiation is caused by the fact that livestock farming involves animals, not plants. Livestock and pens must be monitored by the farmer, and those farms need to make an initial IT investment. Thus, the newly added investment investments of livestock farms are infrastructural IT investments, like RFID and environment mentoring sensor. In conclusion, IT investment into the operation of farms, which includes investment into decision making and management systems, is a key factor of agriculture IT investment for top performance.

This study has the following limitations. This study is limited by the small sample size, with which statistical analysis was not possible. It was practically impossible to obtain the sufficient number of samples required for a statistical survey. However, this study was able to obtain some qualitative insight and understanding. Because this survey was conducted by professional interviewers, the interviewers were able to collect sensitive information such as net income and total capital. Another limitation of this study is that crop farms were not analyzed separately. This also due to the lack of sufficient sample size for different crop types. However, those farms in each crop category have many common features from cultivation to distribution. For example, vegetables and fruits grown in field farms were commonly influenced by seasonality. Thus, the categorization of the farms was based on an understanding of agriculture. Because we reflected on the characteristics of agriculture, we also separated fruits and vegetables into field and greenhouse farms.

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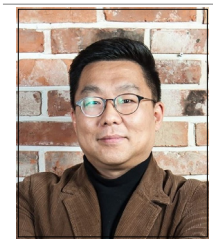

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